Very Wide Angle Surveys with WFIRST

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WFIRST AFTA SDT Meeting

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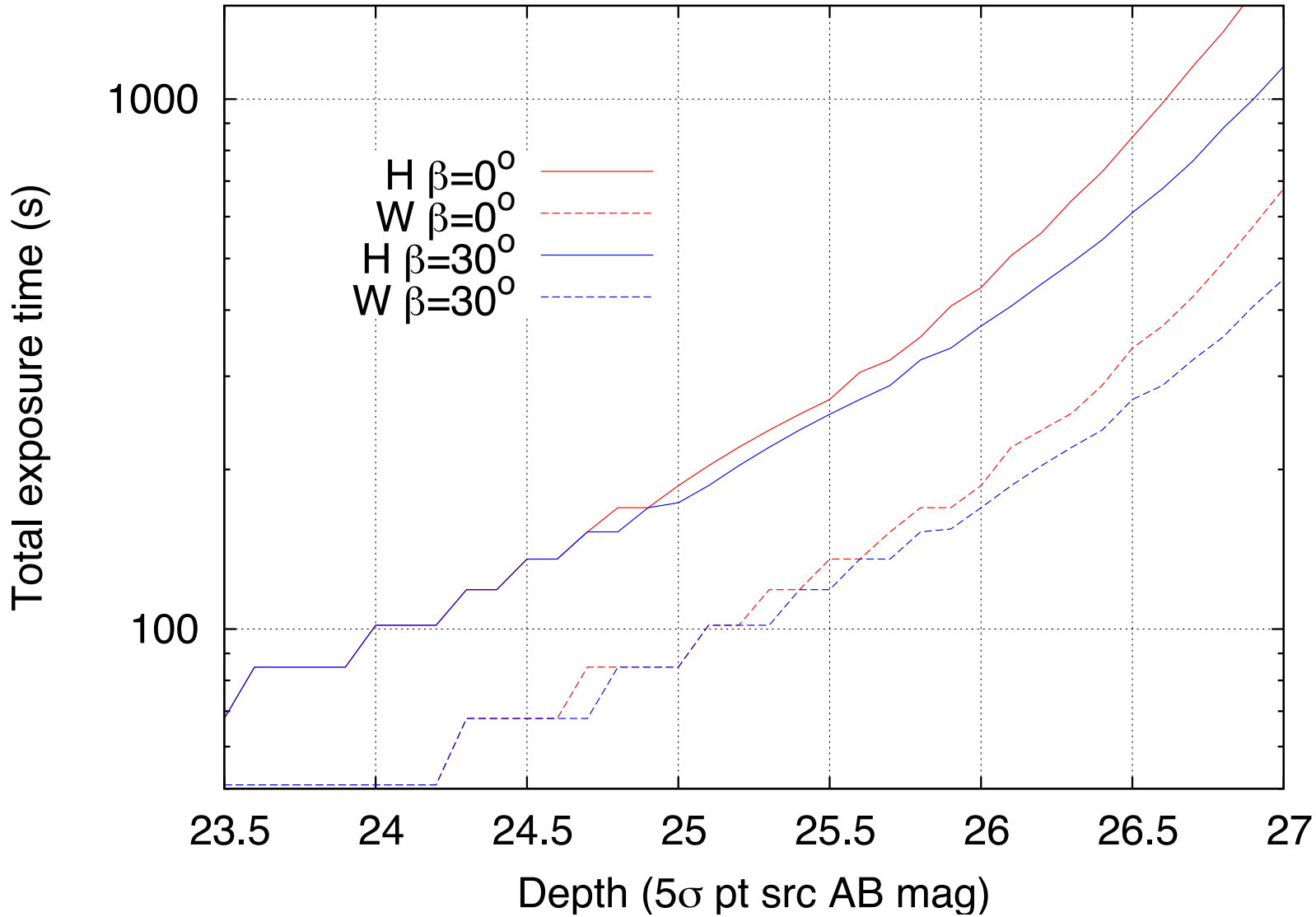
Summary

- We have been charged with considering very large, possibly all sky surveys with WFIRST.
  - This was envisioned as a possible ~ 1 year extension after the primary mission is over but the question is more generally applicable.
- Several cases possible
  - Overlap with LSST: providing a high resolution NIR survey over the entire footprint
  - We were asked specifically about near Earth objects. Only a few brief comments on this, will want to bring in the appropriate expertise and do some sims if this looks interesting.

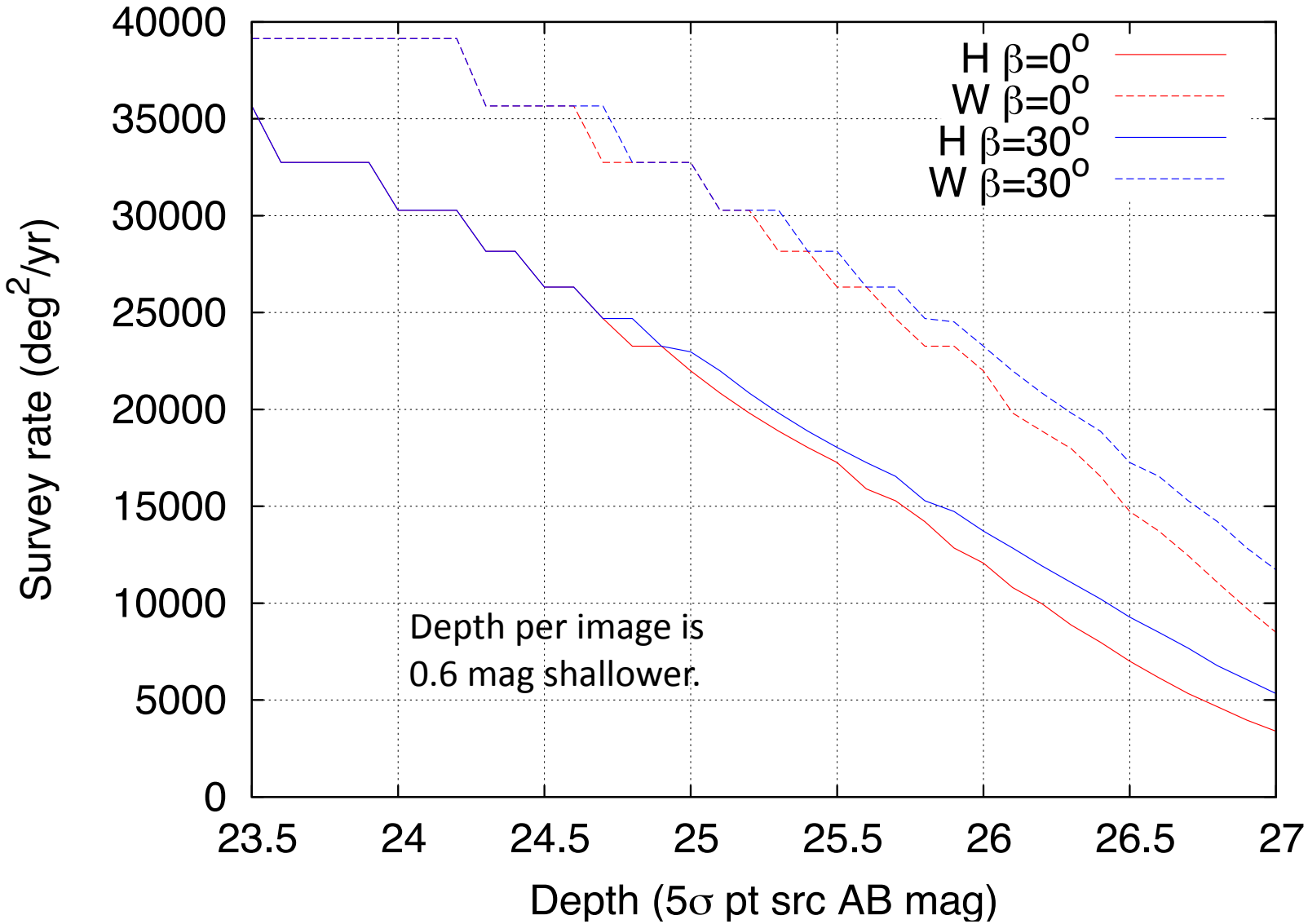
Assumptions

- Survey strategy is 4 observations (2 passes, each one is 2 exposures diagonal-dithered over the chip gap).
- "Depth" is reported for 3 exposures at quadrature (90° from Sun).
  - Coverage is 41% (N=4), 85% (N≥3), 99% (N≥2)
  - 2 cases considered: H band (a likely choice for a single band NIR survey) and the wide/microlensing filter (which gives the maximum possible rate)
- Survey rates are calculated for idealized rectangular tilings.
  - Applied a 20% penalty factor (down time, a few cross-scans for calibration, edge effects, slews to field) on top of normal slew-settle calculation. This is typical of what we have seen for the other wide surveys.
  - Once we converge on a few "candidate" ideas, I will try to schedule them and get an estimate at the level of fidelity of the SDT report.

Observing time



Survey rate


40000
35000
30000
25000
20000
15000
10000
5000
0
23.5
24
24.5
25
25.5
26
26.5
27
Survey rate (deg^2/yr)
Depth (5σ pt src AB mag)
H β=0°
W β=0°
H β=30°
W β=30°
Depth per image is
0.6 mag shallower.

Dark Energy Applications

- A 1-year survey to H~26 AB (5σ pt src; 1 mag penalty at $r_{1/2}$=0.3”) covering 14k deg^2 would be well matched to LSST.
  - Photometric redshifts + NIR morphologies of galaxies.
  - In region of Euclid overlap (β<−15°) would have high resolution 2 filter photometry. Euclid resolution @ I band ≈ WFIRST @ H band – also similar sampling.
- Useful for WL shapes?
  - Predicted 32 gal/am^2
    - With standard cuts – Res>0.4, σ(e)<0.2, S/N>18
  - Probably not useful by itself – no color information, one pass, insufficient sampling.
  - But could you calibrate out the induced systematics on the deep region? What if you also have LSST & Euclid?

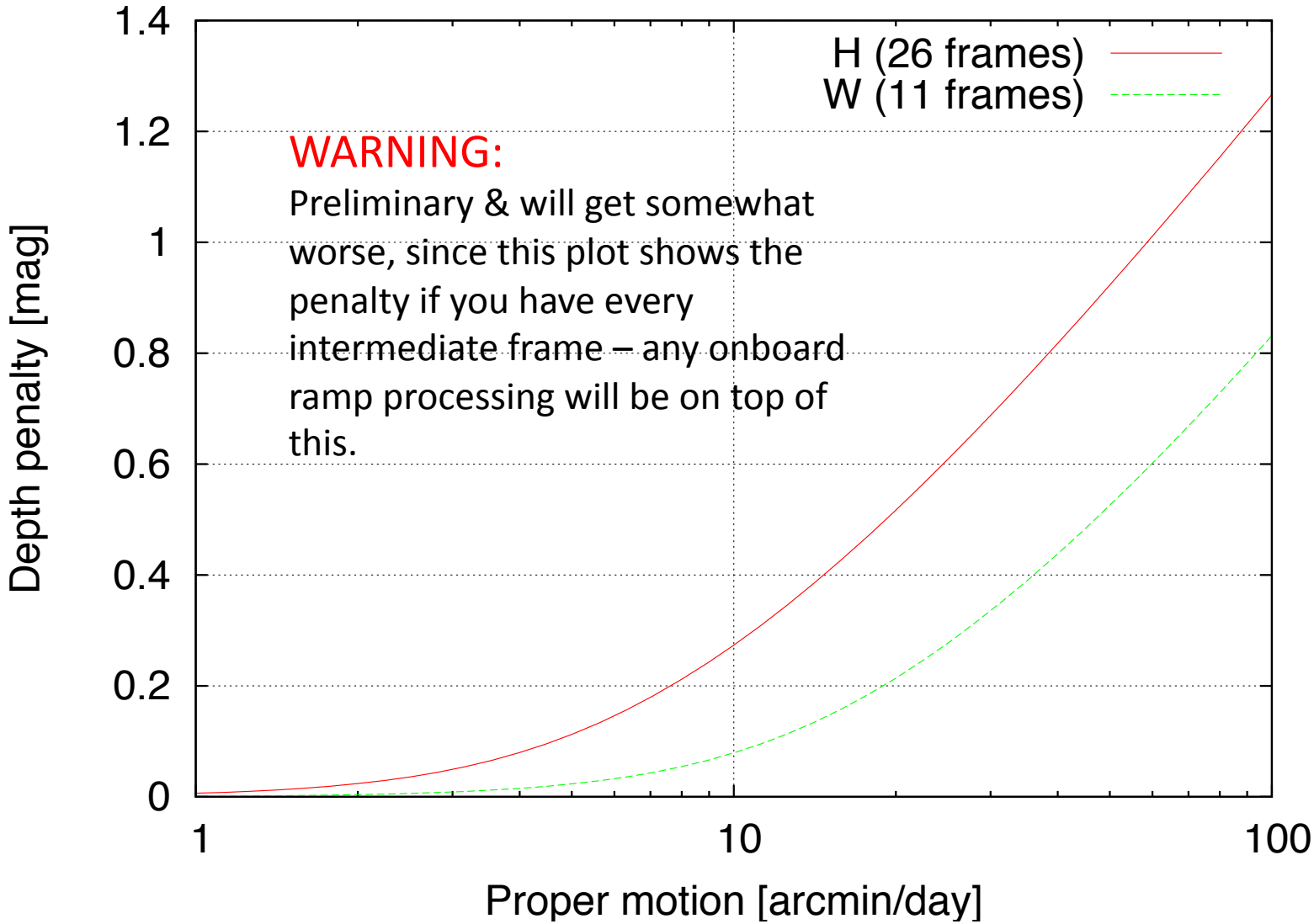
Calibration on Deep Data?

- Concerns:
  1. Beware of subtle variations over the sky!
     - Major issues – large-scale calibration/uniform object selection – is the "deep" region representative to 3 decimal places?
       - In the presence of substantial background (WFIRST), airmass (LSST) variations.
     - Subtle issues – e.g.
       - Galactic reddening changes the PSF of a galaxy; half of the PSF size error budget is used up for a mismatch of $\Delta E(B-V)=0.04$, even for H band shapes!
  2. After applying these corrections to 1 data set, can you convince yourself you didn't miss anything?
     - Need repeatability – this was the motivation behind the original strategy!
- Does having many "wide" data sets (WFIRST + LSST + Euclid) answer this objection?

Other Astrophysical Applications

- I did a quick survey of the community 1-pagers and divided them into 3 groups.
  - Be careful not to over-interpret these kinds of statistics!
  - They are my quick assessments; also N[white papers] ≠ science …
- 27 probably derive no benefit from a Very-Wide survey
- 14 might receive some benefit
  - Examples: proper motions of nearby objects where VW survey provides one epoch; high resolution imaging where it provides one color, etc.
- 8 programs might benefit greatly from a very wide survey
  - Most of these involve synergies with other facilities (LSST, Euclid, …) and require either IR, high resolution, or both. e.g. strong lens searches.

Penalty for detecting moving sources



NEOs

- This is a list of things you might think about – don't take any of this as my endorsement of an idea!
- Detection of moving objects in WFIRST is different from stationary objects.
  - Order of magnitude in the inner solar system is 20 arcmin/day = 15 pixels in a 2 minute exposure.
    - Need to think about data compression.
    - Note: if we only slope & χ^2, a NEO looks like a CR. This is high bandwidth (or algorithm complexity) science.
  - In exposure pairs, proper motion is measured as usual.
- Additional epochs for the orbit.
  - Unique aspect of GEO is large parallax (550 pix @ 1 AU), hence large dPM/dt. Depending on observing strategy this may help or hurt.
  - Might do a separate wide band pass over the low ecliptic latitudes?
  - W to 25.4 (5σ per exp. PM=0) over 5k deg^2 (extragalactic $|\beta|<10°$) is 2.7 months
    - Wide band for NEO detection (e.g. Pan-STARRS) – to let in light and reduce trailing losses
  - Could choose cadence to provide $\lambda\beta$ + PM + π in <1d
  - At this depth, would a "template search" of LSST data over the degenerate orbital elements be a viable option?
- Could reach detection limits fainter than LSST (depending on object color) but in a 1 year survey will be highly incomplete!
- **Need more work + an expert to determine if this is interesting.**

Discussion Points

- Is the very wide survey something we want? Would we give up something else (time) to enable it?
- Relation to other projects – would a very wide/ shallow tier be synergistic with LSST and Euclid, or duplicative?
- Strategy to get a “real” response on the question of whether this mission is useful for NEOs.